Serial No. 09/044,030

REMARKS

Applicants have made minor corrections to the specification. Claim 1, with amendments, has been rewritten as new Claim 13 and Claims 14-19 added, dependent thereon, in order to remove 35 U.S.C. §112 rejections and to clarify the present invention.

The heat pipe cooler, as now claimed, has a receiving plate with first and second opposite surfaces, the heat receiving plate adapted at the first surface to contact an element which generates heat and is to be cooled. At least one heat pipe is provided having a generally U- or V- shaped profile, opposite end portions, and a middle portion between the opposite end portions, said heat pipe fixed at the middle portion to the second surface of the heat receiving plate for thermal conduction, and with the opposite end portions being upstanding with respect to the heat receiving plate, with the at least one heat pipe being sealed at its opposite end portions. A plurality of parallel heat radiating plates are fixed to the at least one heat pipe at each of the opposite end portions, with the parallel heat radiating plates extending substantially parallel to the heat receiving plate. A ventilation duct is provided having an air inlet and air outlet surrounding the parallel heat radiating plates and defining a passage for air to flow through a gap between the parallel heat radiating plates, and a fan is provided producing a current of air through the duct.

Reconsideration and removal of the rejection of the Applicants' claims as obvious in view of a combination of Tajima in view of Sugata, as also combined with August are respectfully requested in view of the present amendments to the claims and the following remarks.

Serial No. 09/044,030

As the Examiner is aware, a heat pipe is constructed in such manner that a small amount of liquid is introduced into a tubular container (pipe) and a vacuum provided in the pipe. A wick (adapted to cause capillary action, for example, layers of thin wire nets) is arranged in the interior of the pipe.

In such a heat pipe, heat is transferred by repeating the following processes (1) to (4). (1) Part of the heat pipe is heated by a heat generating member at a heating area, and liquid is vaporized at the heating area and vaporization takes heat from the heat generating member; (2) vapor is produced in the heat pipe and heat is conveyed all over in the heat pipe; (3) heat is released from the heat pipe at a cooling area remote from the heating area, and vapor is converted into liquid; and (4) concentration of liquid contained in the wick in the heat pipe at the heating area becomes lower than that at the cooling area, so that liquid moves and returns to the heating area by osmotic pressure.

Since the heat pipe is arranged and acts in this way, thermal resistance of the heat pipe is very low, and the temperature of the heat pipe becomes substantially uniform all over the whole outer surface thereof. Generally, since thermal resistance between the heat generating member and the heat pipe and thermal resistance between the heat pipe and are considerably greater than thermal resistance of the heat pipe itself, the heat releasing efficiency of a cooling device including a heat pipe is determined by the heat transfer efficiency between the heat generating member and the heat pipe (hereinafter referred to as the "heat transfer efficiency A") and the heat transfer efficiency between the heat pipe and air (hereinafter referred to as the "heat transfer efficiency B").

Serial No. 09/044,030

In the case of a conventional cooling device including an I-shaped rod-type heat pipe, one end of the heat pipe is thermally contacted at the heat generating member via a heat receiving member, with that one end of the heat pipe embedded in the heat receiving member to a certain depth to ensure a necessary contact area in order to enhance the heat transfer efficiency A.

The heat pipe is contacted at heat radiating fins along the entire length thereof except for the contact area with the heat receiving member in order to enhance the heat transfer efficiency B. The heat radiating fins are arranged at certain intervals and in parallel to the direction of air flow. As a result, the heat pipe passes through the heat radiating fins.

In recent electronic apparatus including this type of cooling device, a compact shape with a reduced height is required.

In this regard, the following two problems exist in the conventional cooling device including an I-shaped rod-type heat pipe.

First, since one end of the heat pipe is embedded in the heat receiving member to a certain depth to ensure a necessary contact area in order to enhance the heat transfer efficiency A, the heat receiving member is thick and the height of the entire cooling device is increased. In addition, since the heat pipe is embedded, it is necessary to carry out precision machining in the heat receiving member, so manufacturing costs also increase.

Second, the following two requirements must be satisfied, and a second problem arises in attempting to satisfy the second requirement. The first requirement is to increase the heat releasing efficiency from the heat pipe to the heat radiating fins. and thus to ensure a sufficient contact area

between the heat pipe and the heat radiating fins. The second requirement is to increase the heat releasing efficiency from the heat radiating fins to the air, and for this purpose, it is necessary to use a large number of heat radiating fins to increase the surface area thereof and thus increase the contact area. In addition to this, it is further necessary to ensure intervals between the fins to a certain degree so that sufficient air flows between the fins, with a large number of fins being provided.

Thus, certain intervals and a large number of fins are necessary, with the result that the height of the entire apparatus is increased.

Assuming a case where it is required to reduce the height of the apparatus to half of the conventional height, it is also required to avoid a reduction in heat releasing efficiency as much as possible, or rather to increase the heat releasing efficiency more than that of a conventional device.

To solve this problem, one may consider reducing the number of the fins to half the conventional number leaving the intervals of the fins unchanged, or to reduce the intervals of the fins to half the conventional intervals with the number of fins remaining unchanged. In the latter case, the heat releasing efficiency will decrease since air flow is obstructed. In this case, one can consider enlarging the outer shape of the fins to increase the surface area two times to compensate for the reduction of the heat releasing efficiency, but the heat releasing efficiency will be increased only a small amount due to the thermal resistance of the fin itself (thermal resistance between an inner portion and an outer portion of the fin). Also, the outer shape of the cooling device is increased in the lateral sense, so compactness is not established.

Serial No. 09/044,030

The heat pipe cooler of the present invention makes it possible to solve the two above described problems while providing compactness.

As a premise, it is supposed that the intervals of the fins are unchanged to ensure a good air flow and the number of the fins is reduced to a half of conventional one.

In order to solve the first problem, the middle portion of the hat pipe, excluding the end portions, is arranged in parallel to the surface of the heat receiving plate, to allow the heat pipe to contact the heat receiving plate over a necessary area, whereby the necessary contact area is ensured without increasing the height of the cooling device, to realize a sufficient heat transfer efficiency A.

In order to solve the second problem, the opposite end portions of the heat pipe are contacted at the heat radiating plates (fins) at different positions, respectively, so that the contact area between the heat pipe and the heat radiating plates is increased to two times the conventional area in which the heat pipe contacts the fin at one position. As a result, the heat transfer efficiency B is ensured without decreasing to half of the conventional efficiency, while the surface area of the heat radiating plates is unchanged (or slightly enlarged). In some cases, the heat transfer efficiency B may be increased.

The present claimed heat pipe cooler, with its advantages is not taught or suggested in the references cited.

Tajima (U.S. 5,729,995) discloses a multi-path container 35 in which fluid is continuously circulated in one direction only, from the coupling portion 35a, through the heat-exchange portion 35c and the header tank 39 to the coupling portion 35a. Heat releasing efficiency will be lower at the later stage in the heat-exchange portion 35c.

The heat pipe of the present claimed invention is different from the multi-path container 35, since in the present invention, heat exchange is carried out equally or in parallel at the opposite end portions of the heat pipe and the condensed fluid returns to the heat receiving plate 3 along separate routes (opposite end portions). Therefore, higher heat releasing efficiency is realized in the present invention. Therefore, the present invention is quite different from Tajima.

Sugata (JP 3-232262) discloses a thermosiphon device 1 comprising a shell-shaped inner curved plate 2, a shell-shaped outer curved plate 3, and a ring-shaped upper plate 4. That is, the thermosiphon device 1 is of a cup-shape. The U-shaped heat pipe of the present invention is quite different from the cup-shaped thermosiphon device 1, as there are no opposite end portions in the cup-shaped thermosiphon device 1. In addition, radially extending heat radiating fins 18 are arranged on the ring-shaped upper plate 4 (see Figs. 3 and 4), but the heat radiating fins 18 are arranged merely to enlarge the contact area with air, and air does not flow through the heat radiating fins 18. Also, air does not flow through the cup-shaped thermosiphon device 1.

Serial No. 09/044,030

The combination of Tajima and Sugata is also not reasonable since Tajima discloses a continuously insulating container cooling device while Sugata discloses a cup-shaped thermosiphon device. Such a combination, even if made, would not provide the present claimed heat pipe cooler with its distinct advantages.

In view of the aforementioned amendments and accompanying remarks, the claims, as amended, are believed to be in condition for allowance, which action, at an early date, is requested.

If, for any reason, it is felt that this application is not now in condition for allowance, the Examiner is requested to contact Applicants' undersigned attorney at the telephone number indicated below to arrange for an interview to expedite the disposition of this case.

In the event that this paper is not timely filed, Applicants respectfully petition for an appropriate extension of time. The fees for such an extension or any other fees which may be due with respect to this paper, may be charged to Deposit Account No. 01-2340.

Respectfully submitted,

ARMSTRONG, WESTERMAN, HATTORI, McLELAND & NAUGHTON, LLP

William G. Kratz, Jr.
Attorney for Applicants
Reg. No. 22,631

Atty. Docket No. 980400

Suite 1000
1725 K Street, N.W.
Washington, D.C. 20006
Tel: (202) 659-2930

WGK/nrp

H:\HOME\NANCY\98\980400 Preliminary Amendment.frm